157 nm Mask Technology Development Status Update

Giang Dao*[a], Ronald Kuse[b], Kevin Orvek[a], Eric Panning[a], Roswitha Remling[b], Jun Fei Zheng[a], Munehiko Tsubosaki[c], and Fu-Chang Lo[a]

Intel Corporation, [a]Components Research, [b]Intel Mask Operations, Santa Clara, CA 95052

[c]Intel K. K., Technology Manufacturing Group-Japan, Tsukuba, Ibaraki, Japan

* Correspondence: Email: giang.t.dao@intel.com; Telephone: 408 765-2569; Fax 408-765-2949

157 nm Mask Technology Development Update

Introduction

- 157-nm lithography is one of the leading candidates for 100-nm and 70-nm nodes.
- In general, material development is the most critical aspect of 157-nm lithography. Conventional materials are virtually opaque at 157-nm.
- In the mask area absorption at 157-nm poses great challenges in several aspects including material and tool development and reticle handling.
- The purpose of this presentation is to provide an overview of the current status of 157-nm mask technology development.

Results of World-Wide Collaborations

157 nm Mask Technology Development Update

Acknowledgment

Asahi Glass, Inc.

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Dai Nippon Printing CO., LTD

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DuPont Photomask Inc.

Hoya Corporation

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n&k Technology, Inc.

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International Sematech

SELETE

University Of Wisconsin, Madison, Mechanical Engineering Department

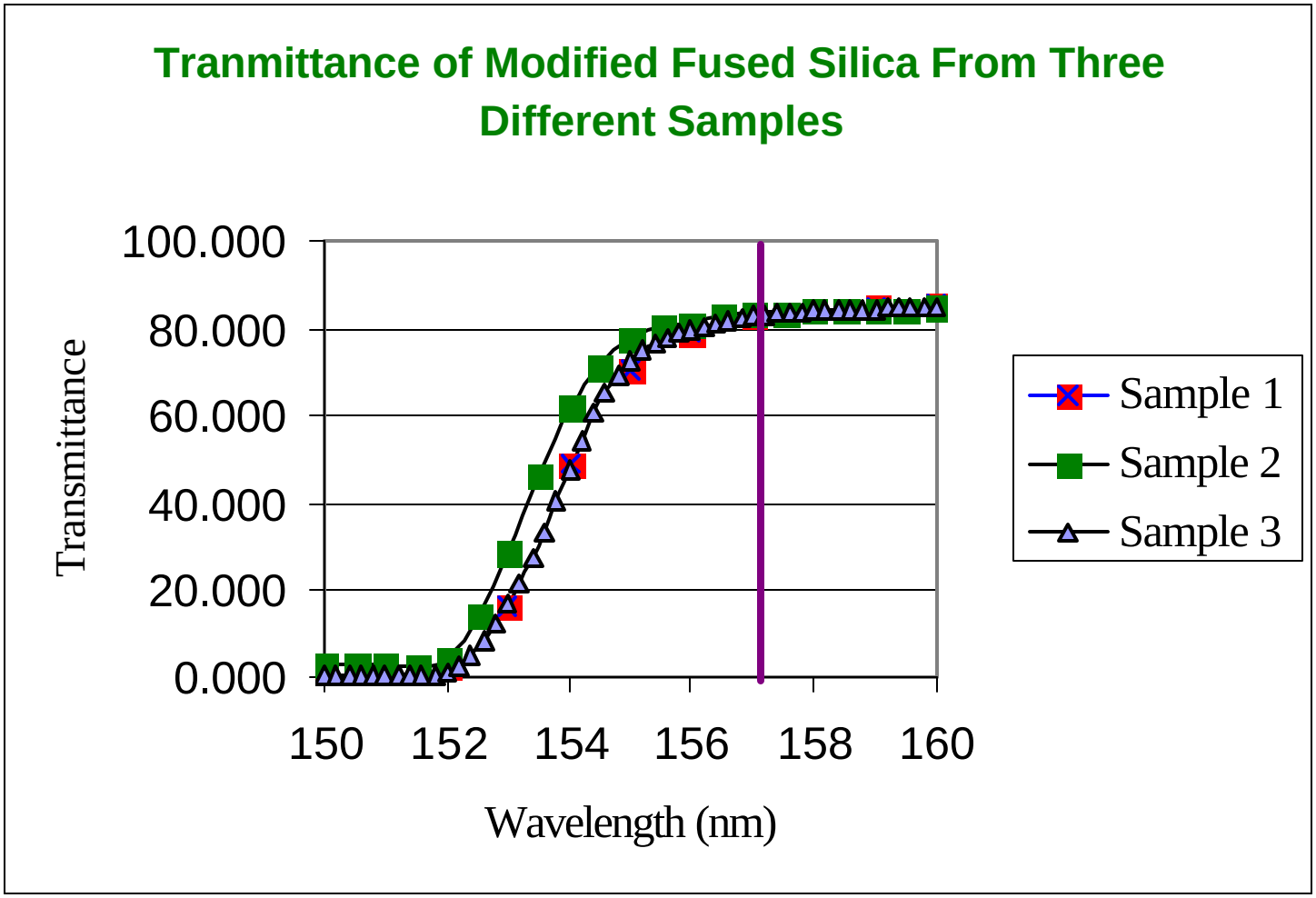
Intel Corporation: Facility Technology Development, Lithography Capital Equipment Development, Mask Operation, Material Technology Operation, and Technology Manufacturing Equipment

157 nm Mask Technology Development Update

Outline

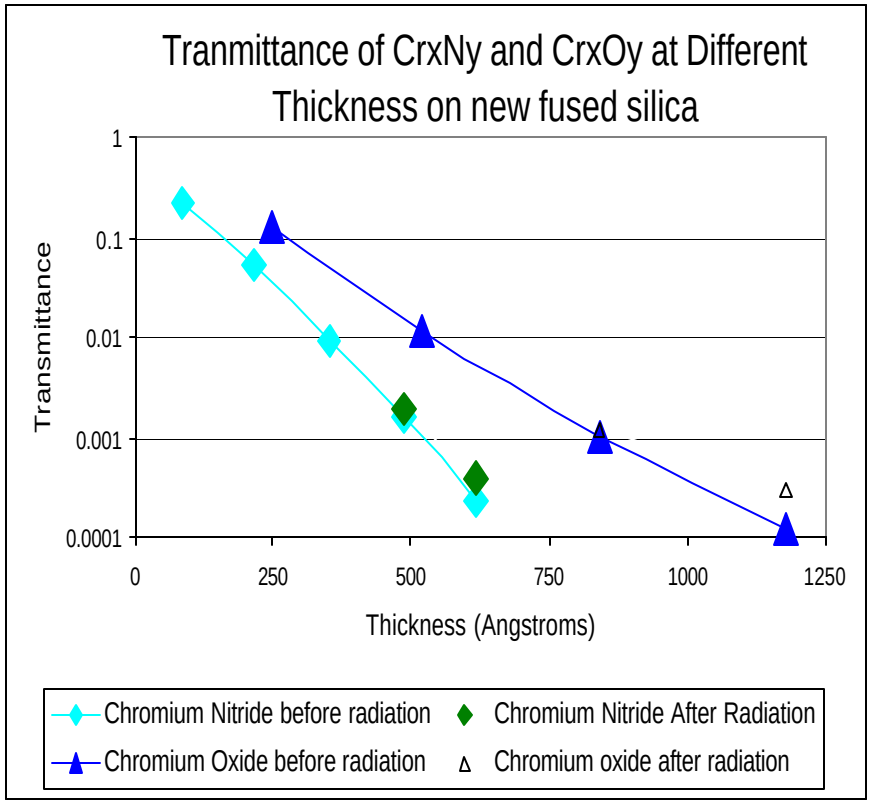
- Mask Material Development Update
- Blank Making Process Compatibility Study Results
- Reticle Making Process Compatibility Study Results
- Wafer level print test result
- Reticle Handling
  - Surface Contamination
  - ESD
  - Particulate Contamination
  - World-Wide Efforts
- Concluding Remarks

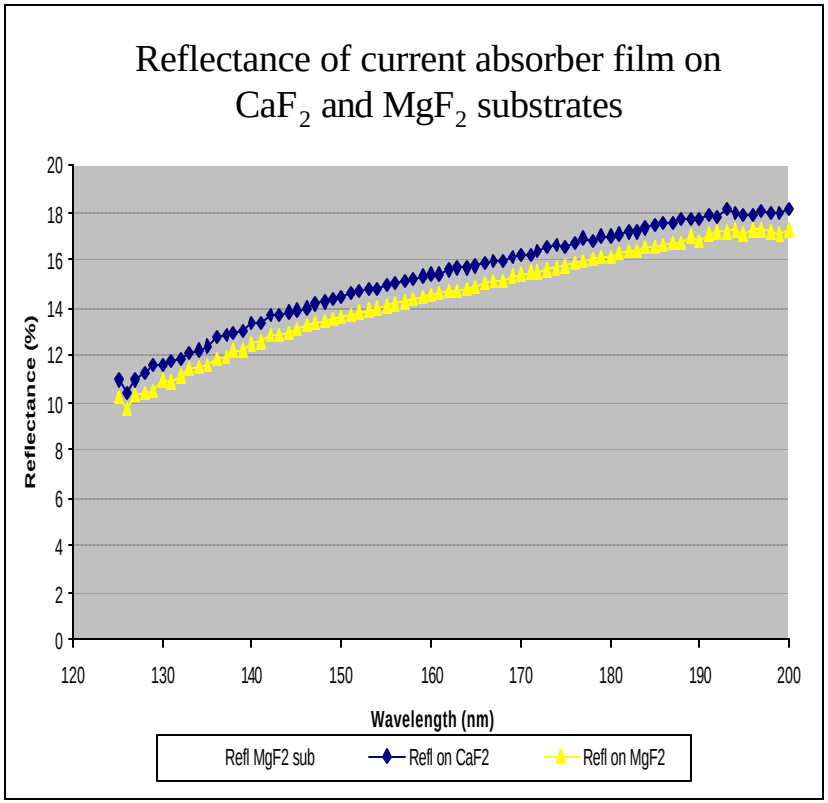
Material Status Development: Blank Substrate



Substrate materials are expected to meet requirements

Material Status: Absorber

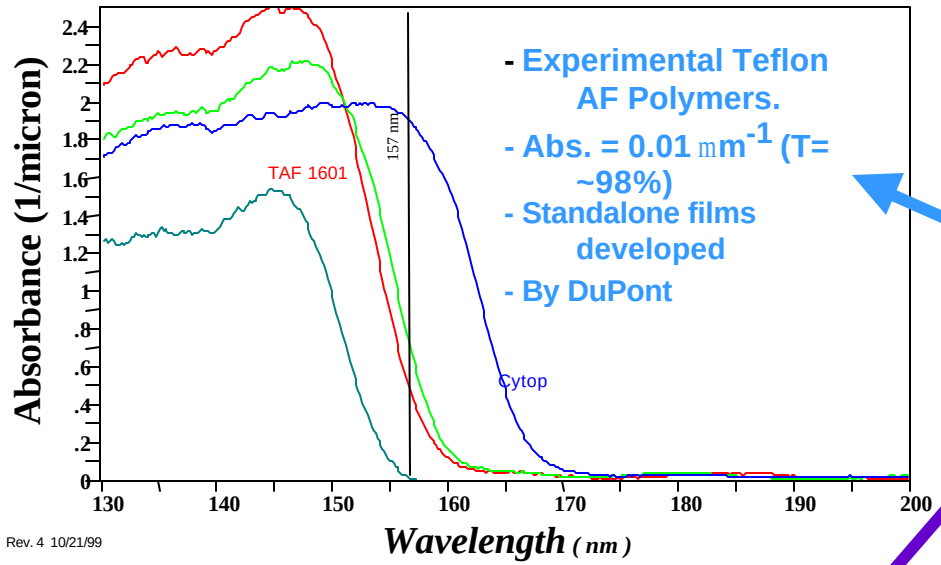


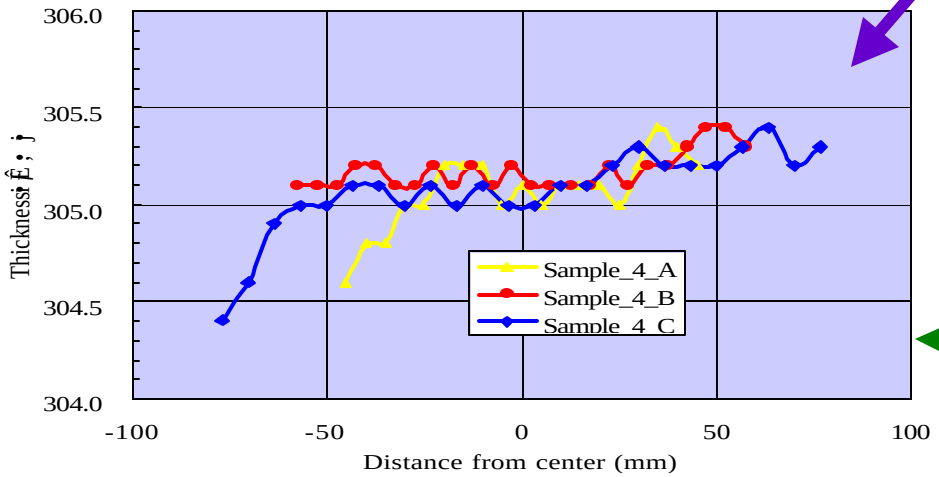


Current chrome-based absorber is suitable for 157-nm lithography from optical point of view

Material Development Status: Pellicle

Polymeric materials (Courtesy of DPI)





- Development on going in the industry world-wide
- Polymeric film samples: Mid '00
- Thin fused silica film samples: Mid '00.

Item	Current	Req'ts
%T	92%	98%
Thickness	>300 u	~300 <200
Tunif./50mm	<0.3 u	<0.1 u

Hard pellicle (Courtesy of Asahi Glass Inc.)

157 nm Mask Technology Update: Blank Making Process Compatibility Study Results

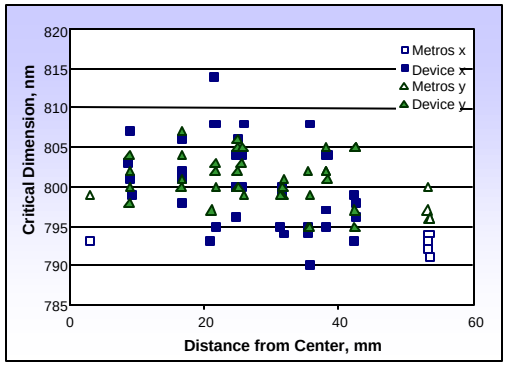
(Courtesy of Hoya Corporation)

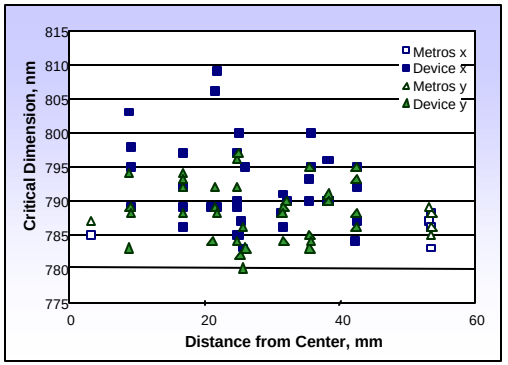
Attributes	# of samples	Sample Number										Results
		1	2	3	4	5	6	7	8	9	10	
Polishing	5						•	•	•	•	•	
Polishing Rate	1					•						Same rate as regular material
Flatness	9	•	•	•		•	•	•	•	•	•	0.72 um (front), 0.80 um (back)/146 mm square
Parallelism	9	•	•	•		•	•	•	•	•	•	Average 2.2 um in 146 mm sq area
Surface Roughness	1						•					RMS: 0.18 nm, typical quality level
Defects	5						•	•	•	•	•	Same level as standard
Fluorescing	9	•	•	•		•	•	•	•	•	•	No fluorescing observed @ 254, and @ 365 nm UV light
R%	9	•	•	•		•	•	•	•	•	•	7.9~8.0% @ 248 nm 10.0~10.8% @ 193 nm
Chrome Adhesion	1									•		Equivalent to standard

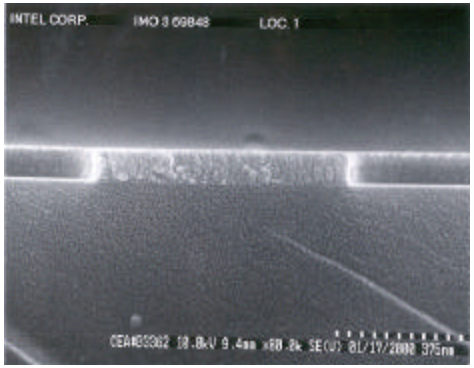
No significant difference was observed in the blank making process

157 nm Mask Technology Update: **Reticle Making Process Compatibility Study Results**

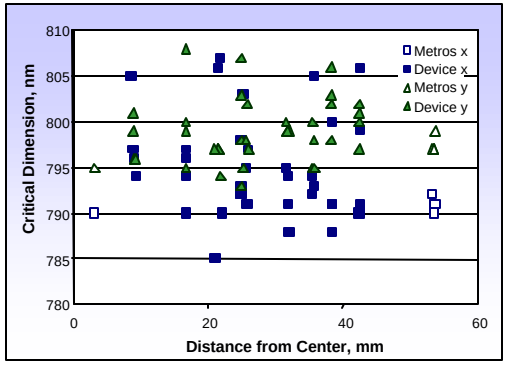
New 157-nm Substrate (180-nm process)

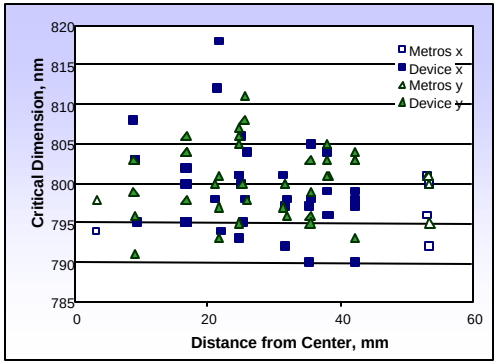


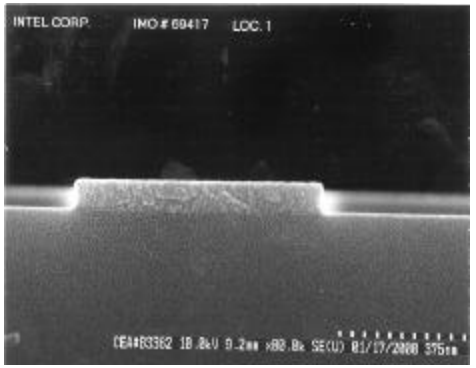




Conventional Substrate (180-nm process)



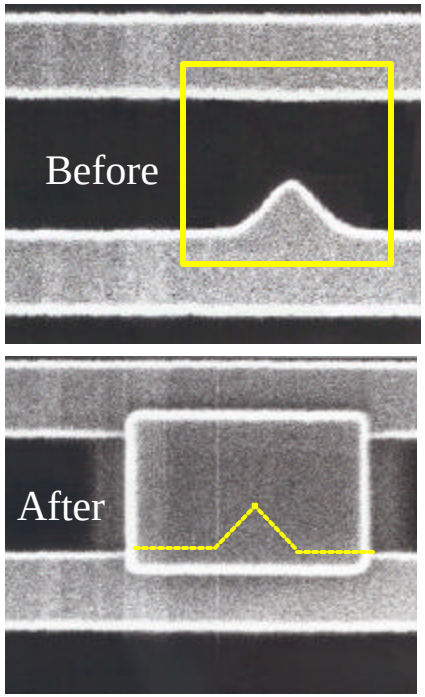


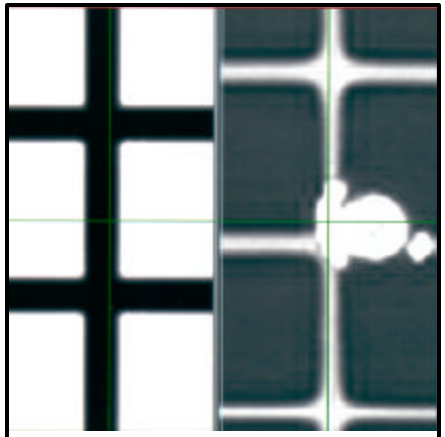


- ✓Registration errors identical on both substrate types
- ✓CD error identical on both types
- ✓Dry chrome etched profile and surface roughness identical on both types

Reticle Making: Defect Study Results

mean ± 1 s	New 157-nm Subst.	Conv. Substrate
Pre-write particles	0.5 ± 0.7	0.0 ± 0.0
Pindot (Cr) defect	1.5 ± 2.1	2.5 ± 3.5
Cr edge defect	1.5 ± 0.7	1.0 ± 1.4
Cr serif defect	0.0 ± 0.0	0.5 ± 0.7
Pinhole defect	1.5 ± 2.1	1.5 ± 2.1
Clear edge defect	1.5 ± 0.7	1.5 ± 0.7
Clear serif defect	0.0 ± 0.0	0.0 ± 0.0





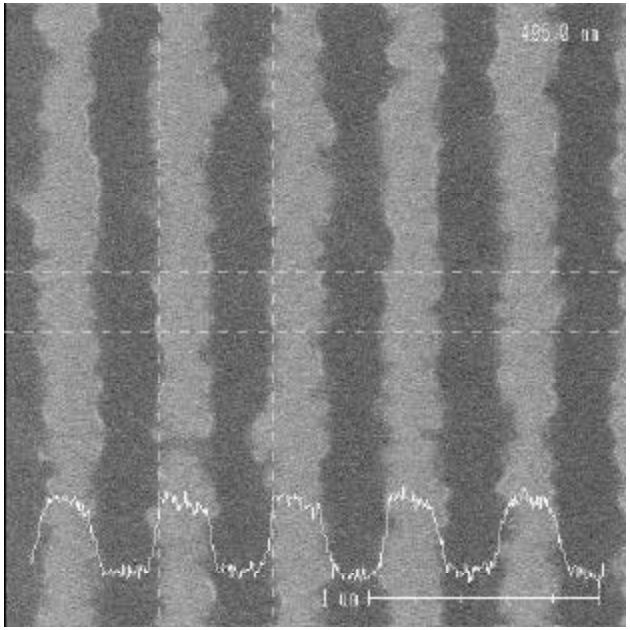
Database (design) pattern *Cr defect in reflected light*

No difference in sensitivity to opaque or clear defect formation

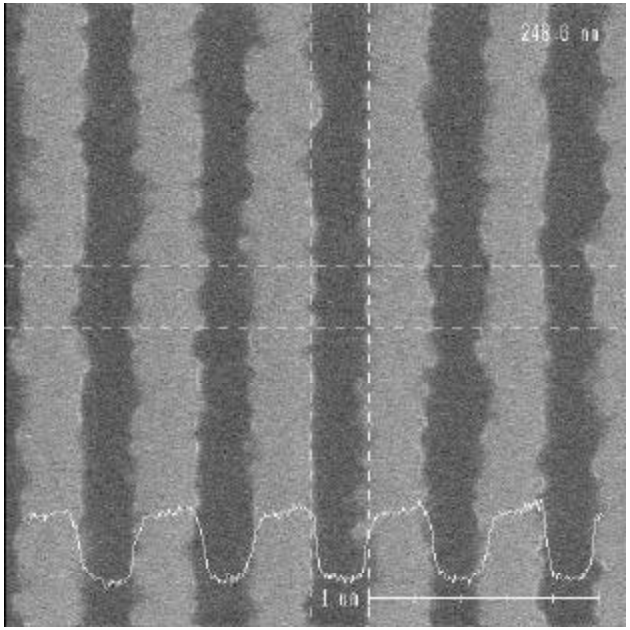
Adhesion of FIB deposition identical on conventional fused silica and 157nm modified fused silica

No difference observed at 180 nm node except that impact of repair on transmission is being investigated

Reticle Making: Wafer Level Print Test



CaF_2 Reticle



New Fused Silica Reticle

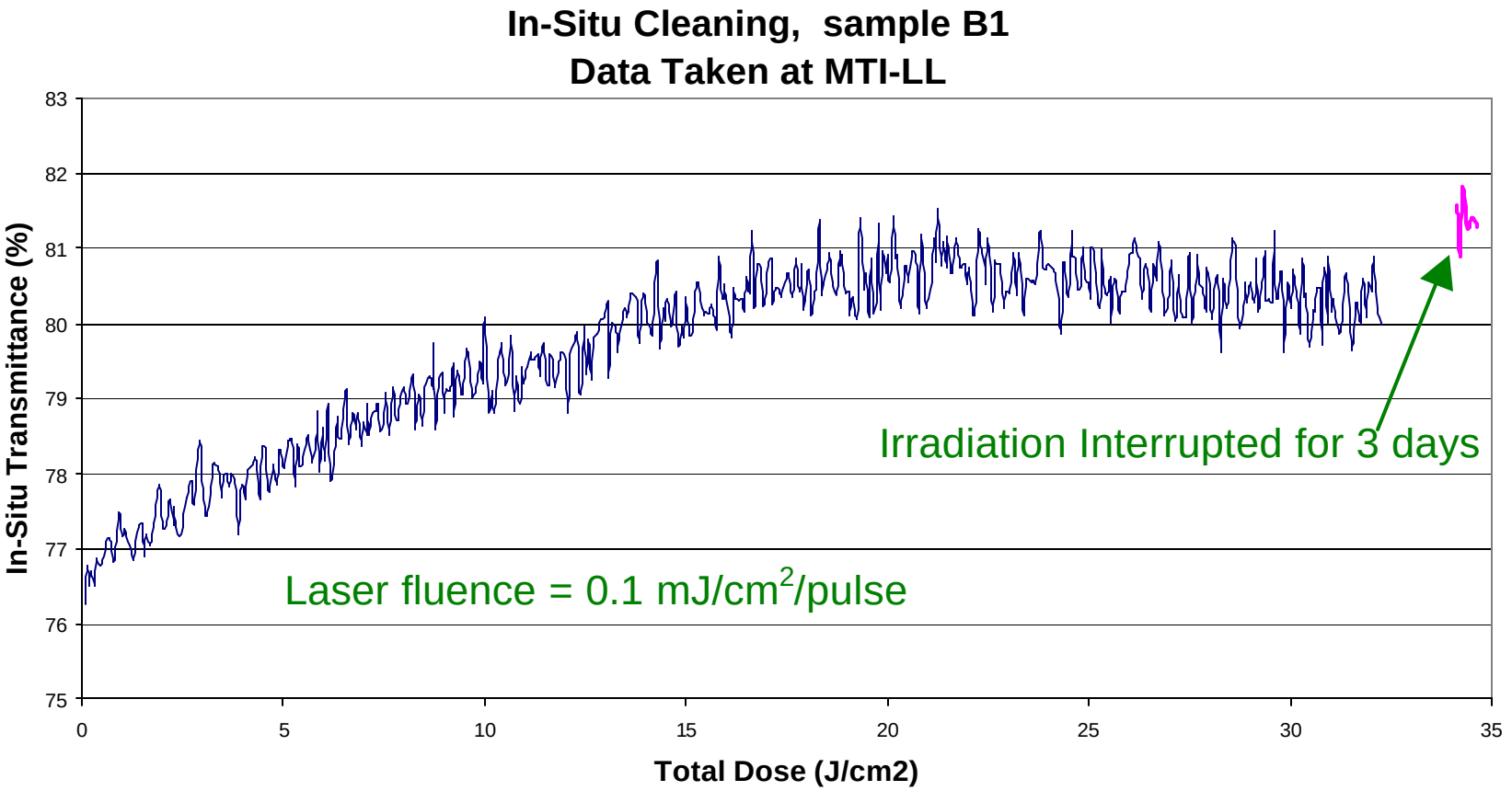
- No difference is observed in print test results between CaF_2 and the new fused silica substrates.
- Detailed study is on going.

Reticle Handling: Current Focus

- Combination of
  - Surface Contamination (molecular contamination)
  - ESD and
  - Lack of viable pellicle material

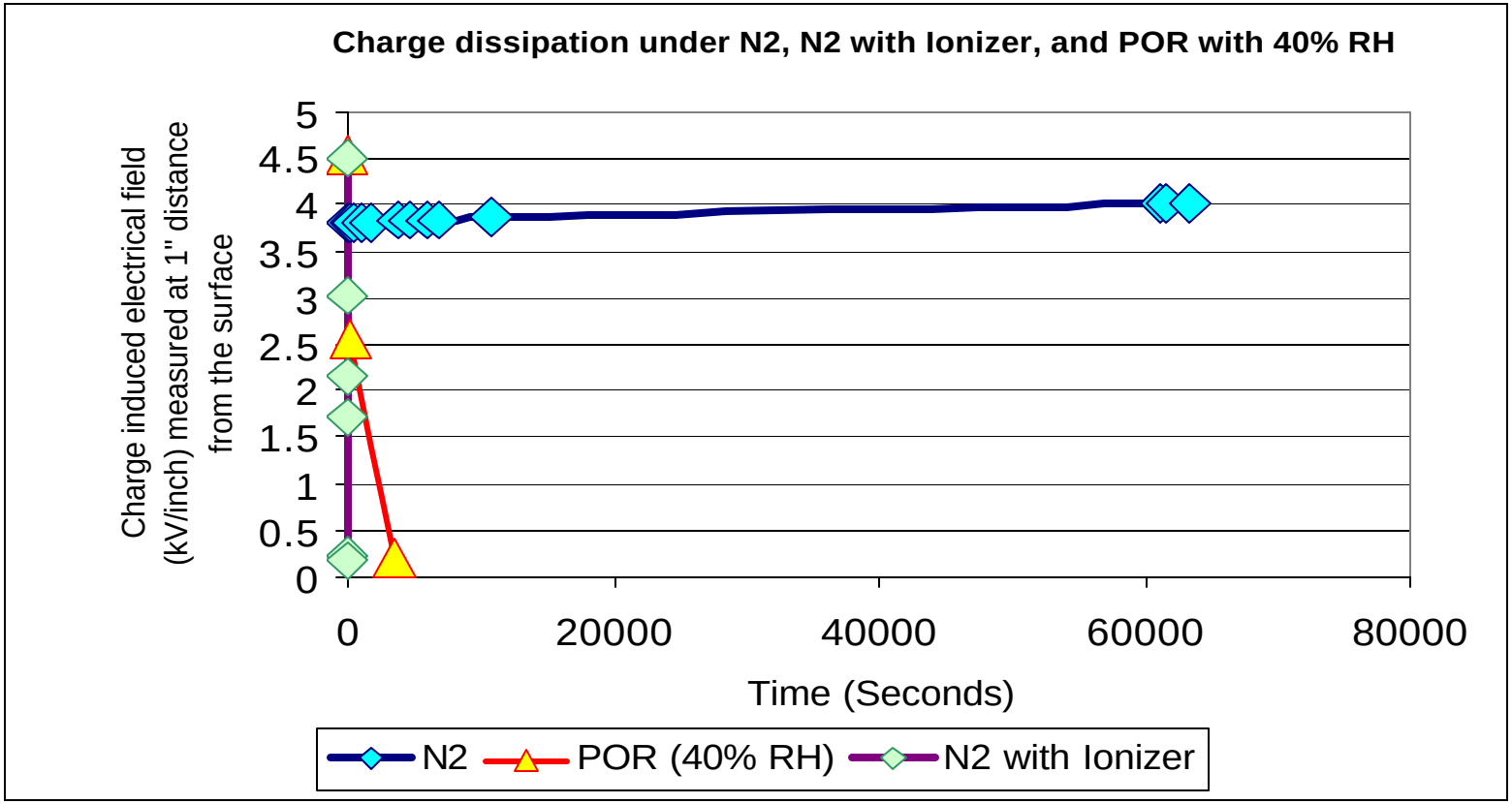
poses *a unique challenge* for 157 nm mask

157 nm Reticle Handling: Surface Contamination



Surface contamination is an issue but solution seems to exist. *In-situ* clean is expected

157 nm Reticle Handling: Electrostatic Discharge



ESD is an issue in a dry environment but technical solution seems to exist (ionizer)

Reticle Protection from Particles: A Major Issue Due Lack of Viable Pellicle Material

- **Options to reticle protection from particles:**
  - *Soft pellicle*: Conventional approach. Material mechanical strength, radiation resistance, and outgassing key issue.
  - *Hard pellicle*: New approach. Meeting stringent requirements is an issue. Significant progress made by Asahi Glass Inc.
  - *Removable pellicle*: proof of concept is needed.
  - *No-pellicle*: *A high risk approach*. ***Particle-free reticle handling*** from final inspection in maskshops, to storage and transport, and in wafer fab is key to success.

Reticle Handling: Current Focus

- WG formed under International Sematech and SELETE with world-wide participation consisting of 4 sub-WG's: pellicle, contamination/clean/standard, handling, and exposure tool. All WG's in motion.
- Schedule: end 6/00 to determine primary and backup approaches, and end of '00 to demonstrate technical feasibility.
- Good progress has been made. Several projects have been identified and initiated.
- Critical data for early indication is expected at the first 157-nm Symposium in May '00.
- Working Group's face-to-face meeting scheduled on 5/12/00

157-nm Reticle Technology Development

Status: Concluding Remarks

- Excellent progress has been made in the area of substrate material development. The material is expected to meet 157-nm mask requirements.
- Current chrome-based absorber material is considered suitable for 157 nm exposure from optical point of view. Optimization may be needed to meet stringent mask CD control requirement.
- Currently there is no viable pellicle material though good progress has been made both in organic pellicle material development and in fabrication of inorganic membrane using new fused silica.

157-nm Reticle Technology Development

Status: Concluding Remarks

- Blank and reticle making process compatibility study results show no significant difference between new and conventional materials using 180-nm technology (except repair impact on transmittance being studied).
- Preliminary print test result show no difference between CaF_2 and new fused silica reticles.
- Surface contamination and ESD are issues for 157-nm lithography but potential solutions seem to exist.
- Reticle protection against particulate contamination remains a critical item for 157-nm lithography if pellicle material is not developed (no-pellicle solution).
- An integrated solution of 157-nm reticle handling is being addressed by a working group under International Sematech and SELETE with good progress.